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AIR QUALITY AND HEALTH HAZARDS AT SKATING RINKS

December, 1994

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The House Committee on Post Audit and Oversight
and the
Post Audit and Oversight Bureau

Commonwealth of Massachusetts
HOUSE OF REPRESENTATIVES

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HOUSE POST AUDIT AND OVERSIGHT BUREAU

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SCOPE OF EXAMINATION:

The House Post Audit and Oversight Bureau (the "Bureau"), under the direction of the House Post Audit and Oversight Committee, (the "Committee") has conducted a preliminary inquiry into the issue of indoor air quality within state and privately owned skating rinks in Massachusetts. Based upon a written complaint, the Bureau began its examination of indoor air quality in skating rinks in January of 1993. The Bureau conducted interviews with rink personnel as well as authorities in the air quality assessment community to ascertain the quality of air within Massachusetts skating rinks. The Bureau also reviewed documents relating to independent air quality studies and current standards in the two states which have regulations or laws relating to ambient air quality inside skating rinks. In addition, the Bureau reviewed a set of draft guidelines developed by the Massachusetts Department of Public Health ("DPH") aimed specifically at indoor air quality in skating rinks.

Initially, the Bureau focused its examination on concerns about the health risks posed by Carbon Monoxide ("CO") gas to rink occupants. After consulting with experts in the indoor air quality field and reviewing several independent reports, it became apparent that other gases such as Nitrogen Dioxide ("NO_2,") also posed potentially serious health risks.

Based on its preliminary inquiry, the Bureau finds that there are sufficient health risks to warrant the immediate establishment of minimum safety requirements for indoor air quality at skating rinks. The Bureau recommends that the safety provisions called for in this report be codified into fully enforceable regulations.

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Compliance with indoor air quality safety provisions should be mandatory for all skating rink operators in order to increase protection of the health and safety of people who use these facilities.

Two incidents which occurred in Massachusetts in recent years have underscored the need for the Commonwealth to develop regulations for indoor air quality in skating rinks. In Rockland in 1991 and Hamilton in 1993, 54 and 59 people respectively, were taken to area hospitals with severe cases of CO poisoning after being exposed to high levels of CO in skating rinks. The source of CO poisoning in each incident was attributed to poorly tuned or inadequately maintained ice resurfacing machines. [1] The Bureau found that these incidents could have been minimized or avoided had regular and proper maintenance of ice resurfacing machines taken place. Proper maintenance of these resurfacing machines is an important procedure for controlling toxic emissions.[2]

In response to the incidents in Rockland and Hamilton, a coalition was established consisting of the DPH, the Department of Environmental Management (the "DEM"), the Metropolitan District Commission (the "MDC"), the Department of Labor and Industries' Division of Occupational Hygiene (the "DOH") and rink owners. This coalition sought to create safety standards for skating rinks by the end of 1994.

The Bureau also found that the potential for exposure to toxic gasses in skating rinks has been significantly understated. The Bureau found that public health experts have identified adverse health impacts that result form exposure to toxic gases in skating rinks.

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[1] Hamilton Document, 1993; Rockland Document, 1991

[2] Bauer and Spengler 1994; p. 432

Virtually all reported incidents of toxic exposure in Massachusetts skating rinks involved extreme cases where many people became seriously ill and required hospitalization. When severe exposure incidents occur, it is relatively easy to attribute the resulting severe illnesses to toxic gas exposure at the skating rink. Based on its own inspections and investigations, the Bureau found that other incidents of unhealthy exposure to toxic gases go unreported because they are not as severe as those requiring hospitalization. This is primarily due to the fact that the general public does not directly attribute the symptoms of toxicity to exposure and therefore may not report ill effects experienced after attending or participating in an event in a skating rink. Symptoms of exposure are often flu-like and may be confused with the influenza virus or the symptoms of the common cold.

The Bureau's examination of indoor air quality in skating rinks revealed toxicity incidents involving adverse impacts to skaters and employees were more common with high levels of CO than with high levels of NO_2. The increased frequency of CO incidents may be due to the fact that symptoms of NO_2 toxicity do not appear immediately after an incident. Consequently, the symptoms of NO_2 toxicity may not be directly attributed to the rink environment by the individuals who are adversely impacted.

POLLUTION SOURCE:

The primary source of harmful pollutants found in skating rinks is the internal combustion engines which power ice resurfacing machines used to maintain ice surfaces. Combustion engine by-products are present in varying degrees in all skating rinks which

employ internal combustion powered ice resurfacers. Gaseous combustion by-products can reach toxic levels in facilities serviced by faulty internal combustion engines or facilities with inadequate ventilation.[3]

Analysis of pollution sources in indoor skating rinks requires the examination of the oxygen to fuel ratio within the internal combustion engines used to power ice resurfacers.[4] In fuel powered ice resurfacing machines, a delicate balance between oxygen and fuel must be maintained. Maintaining the proper ratio is the function of the carburetor which regulates the flow of fuel and oxygen to the engine. If the carburetor provides the engine with too little oxygen: excessive CO is produced. If the carburetor provides the engine with too much oxygen: excessive NO_2 is produced. Therefore, it is imperative, in an indoor environment, to maintain ice resurfacing machines in a manner which insures the proper oxygen to fuel ratio. There is sufficient evidence to support the notion that malfunctioning carburetors in ice resurfacing machines constitute a significant enough pollution source to warrant the implementation of regular maintenance schedule to insure the proper oxygen to fuel ratio.

The inclusion of safety standards relating to NO_2 is warranted due to an increase in the use of propane powered ice resurfacing machines at skating rinks. Propane combustion can produce high levels of NO_2 in malfunctioning ice resurfacing machines. Although the threat posed by exposure to excessive CO appears to be more serious, NO_2 also poses a serious threat to public health which should not be understated.

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[3] Levesque et. al; p. 594 (1990)

[4] Hedberg et. al; p. 3015 (1989)

The Bureau also believes that catalytic converters should be mandated as part of a comprehensive effort to control gaseous toxins. Every rink which employs a fuel powered ice resurfacer to maintain the ice surface should be required to have catalytic converters on the resurfacers. Use of catalytic converters is an inexpensive and effective means of reducing harmful pollutants from both gasoline and propane combustion engines.

VENTILATION:

Regular air exchange or ventilation is now known to be an important factor in maintaining acceptable levels of CO and NO_2. [5] Ventilation procedures at skating facilities have a direct impact on indoor air quality. Good ventilation procedures can dramatically improve and maintain overall indoor air quality. Poor ventilation procedures can facilitate a build-up of toxic gasses inside skating rinks increasing the threat to public health. Although the benefits of good ventilation are known, the Bureau found that ventilation at skating rinks is often limited.

Two significant factors contribute to the practice of limiting ventilation activities at skating rinks. First, in order to maintain a comfortable air temperature for rink users and spectators, rink operators limit the frequency and duration of venting activities involving the exchange of indoor and outdoor air. While such exchanges improve air quality, they generally have a negative impact on the indoor air temperature. Unfortunately, air exchanges

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[5] Hedberg et. al; p. 3017 (1989)

have the capacity to withdraw most of the warm air in the winter and the cooler air in the summer produced in this environment.[6] Uncomfortable air temperatures in skating rinks can translate into a possible loss of business for rink owners because of the potential for a harsh or uncomfortable environment for spectators and youthful participants.

The second factor which contributes to the practice of limiting ventilation activities is the cost of maintaining comfortable indoor temperatures. Heating and cooling costs may increase significantly as a result of good ventilation practices. Increased operating costs obviously subtract from the profitability of skating rinks. The nature of the skating rink business exerts significant pressure to control heating and cooling costs. The Bureau has found that rink owners and operators have employed limited ventilation activity at some skating rinks in order to avoid higher heating and cooling costs. This practice can be dangerous as high concentrations of CO and NO_2 remain in the facility while rink operators attempt to minimize heating and cooling costs.

A condition found in skating rinks known as "Ambient Temperature Stratification" demands ventilation techniques which thoroughly exchange all indoor air with cleaner outdoor air. Ambient temperature stratification prevents cold air near the ice surface from mixing with the surrounding warmer air. The colder air traps the combustion by-products, therefore ventilation techniques which are able to adequately mix air near the ice surface are preferred.[7] This phenomenon means that either more extensive venting procedures are required or the ice

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[6] Paulozzi et. al; p. 25 (1993)

[7] Bauer and Spengler, March 1994

resurfacing machines should expel their exhaust high enough to take advantage of the existing venting equipment within ice rinks.

The Bureau has found documentation that supports the idea of starting and warming up ice resurfacing machines with exhaust fumes directed outside of the facility. In so doing, a portion of the internal combustion by-products is expelled from the facility before the ice resurfacing machine addresses the ice surface. In addition, warm up allows the engine to reach optimum operating temperature which reduces the emission of harmful gasses. This practice is recommended by the New England Ice Skating Managers Association as part of comprehensive plan for effective control of pollutants.

HEALTH IMPACTS:

The combination of high CO and NO_2 emissions produced by internal combustion engines and poor ventilation in rinks creates an environment which is not conducive to the health of skaters or spectators. The severity of health risks posed by CO and NO_2 spans a wide spectrum. Effects of exposure range from minor coughs and other cold-like symptoms to death in extreme cases. Safety standards should be established for participants and spectators alike to protect them while in this environment.

The symptoms of short term exposure to CO and NO_2 are subtle at first, but gradually increase in severity as more time is spent in the toxic environment. CO poisoning is characterized by dizziness and nausea, while NO_2 toxicity can result in lung irritation,

bronchitis, pneumonia and in some cases behavioral alterations. Without corrective action taken to prevent high CO and NO_2 levels in skating rinks, these symptoms and effects can become more serious and eventually may lead to death if persons are exposed to large concentrations of these gases.[8] It is important to note that symptoms of short term CO toxicity will develop very quickly in a toxic environment. However, NO_2 toxicity may not appear until a few days after exposure.

While contaminated air poses risks to all rink occupants, the Bureau believes that it is important to focus on toxicity among athletes in this environment. Because of an athlete's need for oxygen during strenuous exertion, it is crucial for the ambient air to be as clean as possible.[9] Without proper standards in place to ensure air quality, individuals who choose to participate in the indoor arena environment will be at increased risk. Safety standards establishing maximum levels of CO, NO_2 and other gases must reflect the additional need for clean air in skating rinks to protect individuals participating in strenuous exercise at the facilities.

EXISTING STATUTES IN OTHER STATES:

Presently, only two states have regulations requiring safety standards for indoor air quality. Both Minnesota and Rhode Island (which have significant numbers of ice skating

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[8] Kujz, updated, pp. 1-2

[9] Levesque et. al, p. 597 (1990)

rinks) experienced incidents of toxicity, which were attributed to high levels of CO. Both states promulgated regulations in response to these incidents.[10] The state of Minnesota was the pioneer in the area of indoor air quality in skating rinks with standards dating back as far as the mid 1970's. Rhode Island followed in 1990 with similar regulations. Although the DPH has proposed guidelines relating to indoor air quality in Massachusetts skating rinks, no enforceable regulations exist.

Minnesota's regulations were based upon the National Primary Ambient Air Quality Standards for CO and NO_2.[11] Minnesota's safety standards include weekly monitoring of gas levels by rink personnel, accompanied by log entries to verify monitoring. If any violation of Minnesota's 35 ppm for CO and .5 ppm for NO_2 standard occurs, immediate corrective action is required. Corrective action may take the form of increased ventilation and/or decreased resurfacing activities by the ice resurfacing machines. In the event that CO levels exceed 125 ppm and NO_2 levels exceed 2 ppm the facility must be closed and evacuated immediately.

Rhode Island's legislation is very similar to Minnesota's with respect to monitoring and safety standards. The process by which Rhode Island adopted its language was one of consensus between officials at Rhode Island's Department of Health and rink owners. Both groups recognized the importance of monitoring to ensure public safety. Rink owners supported a plan for state monitoring which was eventually adopted.

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[10] Anderson (1971)

[11] Ch. 40 CFR, part 50.8 and 50.11

The state official responsible for monitoring CO and NO_2 levels in Rhode Island conducts two inspections of the state's thirteen (13) rinks per year, and collects a $105 fee from each rink. Random unannounced inspections have proven to be an effective manner of enforcement for Rhode Island. The Bureau did not find evidence that Rhode Island had experienced any major indoor air quality problems in skating rinks since it enacted its legislation.

The Bureau recognizes that the Rhode Island legislation does not include safety standards for NO_2 toxicity. This is due, in part, to the fact that Rhode Island officials did not attribute the same sense of urgency to the problem of NO_2 toxicity as they did to CO toxicity. While the Bureau understands Rhode Island's decision to focus on CO gas due to its potency as a toxin, the Bureau found that NO_2 exposure is also a serious threat to public health and should also be addressed.

MASSACHUSETTS REGULATIONS:

The Commonwealth does not yet have enforceable regulations that directly relate to indoor air quality in skating rinks. The DPH has developed draft guidelines and is currently working to develop indoor air quality regulations. The only required indoor air quality standards in Massachusetts that could be found were at the Department of Labor and Industries' Division of Occupational Hygiene (the "DOH"). These standards relate to employees only, and do not address the concerns raised in this report.

The Bureau examined the conditions and operations at numerous rinks around the metropolitan Boston area both public and private. The Bureau observed a number of rinks

which did not utilize ventilation procedures during warmer weather. The Bureau also noted at two of the rinks visited that the exhaust fumes from the ice machine were clearly noticeable several minutes after the ice resurfacing machine had left the ice surface. The Bureau believes that these fumes were indicative of poorly tuned machinery. The Bureau had concerns that if exhaust gasses were easily detected, then larger amounts of odorless and more toxic gasses may also have been present.

RECOMMENDATIONS:

The Bureau believes that there is a clear and immediate need for enforceable indoor air quality safety standards at Massachusetts skating rinks. Based on the Bureau's investigation, it has become apparent that individuals who are participating, working at, or viewing events at a skating rink may be at risk from toxic levels of CO, NO_2 and other gases. Although major incidents involving high concentrations of CO and NO_2 appear to be infrequent, prolonged exposure to either of the two gases at levels of 36-125 ppm for CO and .5 or higher to 2 ppm for NO_2 present serious concerns which warrant specific safety regulations. Regulations requiring strict compliance should fully incorporate the Bureau's following recommendations and findings:

1. There is significant potential for adverse heath impacts that can result from poor air quality at indoor skating rinks. Air quality at skating rinks can be substantially impaired by poorly tuned ice resurfacing machines.
2. DPH should immediately establish CO and NO_2 safety standards to protect participants, spectators and employees from the dangers of CO and NO_2 toxicity in Massachusetts skating rinks.

3. DPH should require regular maintenance of ice resurfacing devices used in all Massachusetts rinks. Ice resurfacing machines that are properly tuned and maintained are less likely to produce CO and other harmful gases. Because of the frequency of malfunction, specific attention should be paid to the resurfacing machine's oxygen to fuel ratio.

4. The Bureau recommends that ice resurfacing machines be inspected biannually by a state licensed inspector. Biannual inspection would identify potential problems that may occur with ice resurfacing machines that are operating in an inefficient and potentially threatening manner.

5. Ventilation before, during and after the use of an ice resurfacing machine must be standard practice in all Massachusetts rinks. Experts agree that the use of exhaust fans and proper ventilation techniques are effective tools in maintaining low levels of toxic gases.[12]

6. Rink personnel should start and warm up internal combustion engine resurfacing machines with the exhaust fumes directed outside the arena or in an area that is adequately vented. This measure may help reduce the amount of combustion by-products generated during the initial start up of the ice resurfacing machine.

7. The Bureau recommends that all ice resurfacing machines be equipped with a catalytic converter mechanism. Catalytic converters an effective device for controlling toxic emissions.

8. Monitoring devices for both CO and NO_2 levels should be instituted in all Massachusetts rinks. Daily logs of readings of monitoring services should be kept and made available for viewing by both the state inspector as well as the general public. If CO and NO_2 levels reach one hour averages of 125 ppm and 2 ppm respectively, it should be standard operating procedure to close the facility until acceptable levels are attained.

9. Massachusetts should explore the use of alternatives to internal combustion ice resurfacing machines. The Bureau found that electric powered resurfacing machines or mechanisms to vent exhaust gases directly outside are two options. Electric ice resurfacing machines do not generate the harmful combustion by-products that internal combustion engines do. The Bureau notes that it was previously thought that propane powered ice resurfacing machines

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[12] Lee et. al, p. 771 (1993)

were a possible solution to high levels of CO; however, propane combustion is now believed to be one source of higher NO_2 concentrations found in skating rinks.[13] The Bureau recommends that propane powered ice resurfacing machines be required to adhere to strict maintenance schedules.

10. All incidents involving indoor air quality problems at rinks should be reported to a central repository within the Department of Public Health. This central file would aid the Commonwealth in tracking and assessing indoor air quality conditions in rinks.

11. The Commonwealth should designate a qualified hygienist to inspect Massachusetts rinks for compliance with adopted regulations relating to indoor air quality. The hygienist would conduct unannounced inspections to confirm code compliance at least once a year.

12. The Bureau also recommends that an educational program be established to highlight the dangers of CO, NO_2 and other gases found in the indoor air environment. The education program should also focus on what procedures should be followed in order to avoid exposure to toxic fumes. These programs would alert rink operators, as well as the public, of the potential dangers that are present in this environment.

13. The Bureau recommends that a grant program be established to assist in defraying the cost of compliance with required safety measures.

CONCLUSION:

The Bureau believes that the Commonwealth should adopt strict safety regulations to ensure public safety in Massachusetts skating rinks. Massachusetts citizens have a long and proud history of taking part in activities at skating rinks. Our rinks have been the spawning ground for both Olympic medalists and professional athletes. In addition, they have provided endless recreational enjoyment to those who use them. The threat of health risks incurred as a result of exposure to toxic gasses inside Massachusetts skating rinks should be eliminated.

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[13] Bauer and Spengler, p. 430 (1994)

Rink users should be assured that the skating rinks that they use are safe and free from toxic pollution. The creation of enforceable safety standards which incorporate the provisions highlighted in this report is a necessary step towards providing that assurance.

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